New Brunswick Forest Land Habitat Project

Progress Report

October 1989

A Cooperative Project Supported by:
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Natural Resources and Energy / Ressources naturelles et Énergie

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FOREST LAND HABITAT MANAGEMENT IN NEW BRUNSWICK

PROGRESS REPORT

Fish and Wildlife Branch
Department of Natural Resources and Energy
Fredericton, New Brunswick
E3B 5H1

Submitted to

WILDLIFE HABITAT CANADA

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PROGRAM DESCRIPTION

The objective of the Forest Land Habitat Program is to develop a system that integrates wildlife habitat objectives into the 25 year forest management planning process used on Crown Land in New Brunswick. To accomplish the objective the program must: 1) establish quantitative relationships between wildlife populations and forest habitats, 2) identify long-term wildlife habitat objectives, in terms of forest structure, that will accommodate desired wildlife population levels and, 3) develop the computer procedures and management approaches that can integrate these objectives into the system used to determine annual allowable timber harvest levels for Crown Timber Licenses. Such an integrated forest management planning system will quantify wildlife and wood fibre resource response to different forest management scenarios.

PROJECT STAFFING

Position	Name	Status
Project Leader (DNRE)	M. Sullivan	Acting
Habitat Relationships Leader (WHC)	D. Beaudette	Acting
Habitat Relationships Biologist (DNRE)		Vacant
Habitat Relationships Biologist (DNRE)	J. Niederleitner	Contract
Habitat Relationships Biologist (DNRE)	M. Elderkin	Contract
Habitat Coordination Leader (DNRE)	M. Sullivan	Permanent
Habitat Coordination Biologist (WHC)	S. Gordon	Contract
Computer Systems Leader (DNRE)	L. Vietinghoff	Permanent
Computer Systems Specialist (WHC)	J. Feltmate	Contract
Technician (DNRE)	J. Kennedy	Casual
Technician (DNRE)	J. Haines	Casual

Michael Sullivan is acting as Project Leader in addition to his other duties as Habitat Coordination Leader. Daniel Beaudette is acting Habitat Relationships Leader. A competition to fill the positions of Project Leader and Habitat Relationships Leader is in the process of being advertised. Joseph Kennedy has been hired for 6 months to assist in the implementation of the deer wintering area habitat management strategy. Joanne Haines has been hired for 3 months to assist J. Kennedy and to quantify the amount of area of different forest types located within riparian zones.

1. HABITAT RELATIONSHIPS DEFINITIONS

TARGET SPECIES

Initial habitat relationships have been defined for beaver, american marten, moose and white-tailed deer and are currently being defined for forest songbirds. However, refinement of relationships during the past six months has been limited to those concerning american marten and white-tailed deer, the two species for which Habitat Supply Analyses (HSA) will be conducted for the 1992 Forest Management Plans.

MARTEN

The marten habitat model was redrafted in October 1989. It operates using WILD, a modified version of the FORMAN wood supply model.

In order to model wood supply using FORMAN, the forest on each license was stratified into a manageable number of units. Vegetative attributes used for the stratification included Forest Unit and Development Stage. Forest unit (FU) is a descriptor of overstory tree species composition; FUs were assigned to each stand on the basis of more detailed photo-interpreted attributes. Development stage (DS) is a descriptor of rate of change in wood volume of a stand, though it is closely related to stand successional stage. DSs were assigned to each stand from photo-interpretation. FUs and DSs are described more fully in Appendix 1. Combinations of FU and DS are Forest Classes (FC). FCs are the units to which volume growth equations were assigned to model future wood supply; they also represent the level of resolution at which the forest is logged (i.e., blocks of contiguous stands of the same forest class are assigned to be harvested in the same operation).

The marten model is similar in structure to those developed by the USDI Fish and Wildlife Service as part of their Habitat Suitability Index series. It assesses the value of a stand to marten on the basis of its forest structure, as referenced by its FC assignment. It is useful as a proactive management tool because requirements for maintenance of areas of certain FCs can readily be incorporated by the licensee at the planning stage. The model is given in full in Appendix 2.

The size of patches of suitable habitat and the distance between patches may be as determinant of marten use as are their vegetative structures. However, very little information is available on the spatial attributes of marten habitat. In an attempt to correct this deficiency, a questionnaire was sent to 26 marten researchers in North America. Many responses have been received; ideas about the spatial attributes of habitat are being revised accordingly.

The use of WILD to assess marten habitat does not allow for a stand's location or size to be considerations in assigning it a suitability. Therefore, for at least the 1992 management plans, marten habitat will be defined manually as areas meeting both the composition criteria, as outlined in the model, and the spatial criteria of patch size and inter-patch distance. Maps are being produced upon which stands are identified as to suitability for marten. These are similar to maps already used by licensees upon which forest stands are identified as to which of five 5-year periods they are scheduled to be harvested in. Licensees will be responsible for ensuring that the required area of suitable forest classes are maintained in suitable spatial configurations.

Confidence in definition of composition and spatial attributes of marten habitat will be increased through field study. The formulation of critical questions about marten habitat and the design of efficient field methodologies are priorities within the Habitat Relationships section.

WHITE-TAILED DEER

The life requisites of white-tailed deer are summer food, winter food, security cover and winter thermal cover. To address the question of habitat supply for white-tailed deer, a model was constructed that assessed the suitability of an area for white-tailed deer based on both the abundance and the interspersion of the above requisites. Inputs to the model were vegetative structure and location of stands. Stand vegetative structures were referenced by their Forest Class assignments; stand locations are referenced in the provincial Geographic Information System database. Trial runs of the deer model indicated that, of the 4 habitat requirements, winter thermal cover is the component that most likely limits habitat suitability. Although stands providing winter food appear abundant, their contribution to white-tailed deer habitat supply was seen as highly dependant on the degree to which they also provide winter thermal cover or are in close proximity to stands that do. The management strategy for white-tailed deer (See: 2. Licensee Habitat Objectives) is therefore primarily concerned with the maintenance of stands providing both suitable winter cover and suitable food. Further refinement of white-tailed deer habitat relationships has been limited to those concerned with winter requirements.

Winter Habitat Requirements

During periods of cold and (or) deep snow, white-tailed deer exhibit a net energy loss. Areas selected by deer in winter (deer wintering areas) provide forest structures that reduce that loss.

The principal causes of energy loss during winter are locomotion through snow and thermoregulation. The energetic cost

of travel to deer is directly related to snow depth. The energetic cost of thermoregulation is inversely related to the degree of thermal reradiation provided by the forest canopy. Forest stands with high coniferous crown closures are effective at reducing energy loss by interception of snowfall and reflection of thermal radiation back to the ground.

Energy is gained by deer in winter by feeding on deciduous browse. The primary regulator of browse growth is the incidence of sunlight. Forest stands with low crown closures, therefore, yield high browse biomass.

It is apparent that overstory conditions that yield high browse biomass are not effective at reducing energy loss. The ability of stands to simultaneously intercept snowfall, reradiate thermal radiation and stimulate understory browse production implies that ideal conditions are most likely met in stands where crown closure is heterogeneous with patches of both high and low closure.

Winter Habitat Relationships

Predictions about changes in softwood and hardwood volume over time were made by the forest licensees for each forest unit that occurs on their licenses. These predictions form the basis for the volume yield curves used in the wood supply model. Though rates of wood volume change vary among forest units and among licenses, the yield curves are similar in that no standing volume is present when the forest is at the beginning of the Cut development stage, volume increases through the Cut, Regenerating and Immature stages, volume is stable in the Mature stage and volume decreases in the Overmature stage. A volume yield curve is a form of forest succession model; volume is simply the output variable of interest to wood supply planners. The period over which a forest unit is suitable as deer winter habitat can therefore be described as a window on the wood volume curve for that unit; classes are predicted to begin supplying deer winter habitat at a given age and to stop supplying it at a later age. Data on winter use of forest stands by deer collected during the Forest Land Habitat Programs 1986, 1987 and 1988 DWA winter field surveys will be used to determine shelter habitat windows for the 1992 forest management plans.

Coniferous crown closure is closely associated with coniferous stem density (number of trees per unit area) and coniferous basal area (sum of tree diameters per unit area). Changes over time in stem density and basal area can be predicted relatively accurately, whereas changes in crown closure are difficult to predict. Knowledge of winter habitat selection by deer in terms of stem density and basal area would allow more accurate predictions of when forest units provide suitable winter habitat, and hence allow more precise placement of winter habitat

windows on wood volume curves. Few data on stem densities and basal areas in DWAs are available, limiting the use of this approach at present. A preliminary field study to assess efficient ways of collecting needed data is currently underway with the intent of undertaking a full scale field study during the winter of 1990.

FOREST BIRDS

Data on habitat use by forest songbirds were collected by the Canadian Wildlife Service (CWS) during 1988. The intent was to identify forest class/songbird associations. The study was funded, in part, by the Forest Land Habitat Project. Forest birds on Crown Land were identified as a shared management responsibility of the CWS and DNRE. However, as the CWS was unable to further support the program, DNRE implemented a forest bird program on its own in July 1989.

The 1988 field data were analyzed in an attempt to identify preliminary relationships and to refine methodology in order to continue data collection in 1990. Very high variances in use of forest classes by bird species indicated that much larger (prohibitively large?) samples were required. A reevaluation of the approach led to a suspension of data collection.

Forest class preferences and unique habitat requisites of forest birds have been defined using the literature, the 1988 data, the Maritime Nest Records Scheme and the Breeding Bird Survey data as sources of information. The intent was to classify the 101 species of forest birds into one of 3 categories:

1. Unable to define habitat given the resolution of Forest Development Survey (FDS) information.

2. Able to assign forest class preferences; required classes are components of managed forest.

3. As above, but required classes may not be components of managed forest.

Tentative conclusions from the classification procedure were:

1. Habitat definition in terms of forest class is possible for 46 of 101 species. Preferential use of forest microfeatures renders most others unsuitable for habitat supply analyses using current FDS attributes.

2. Of the 46 species considered, none are limited by obligative associations with single forest classes or forest units.

3. Sustained yield forest management will not impact most forest bird populations in New Brunswick over a long term. Species that may be impacted are those that require microhabitat features that may not be present in forests managed on a short rotation and (or) under an intensive silvicultural program. Future work will focus on these species.

2. LICENSEE FOREST HABITAT OBJECTIVES

Inherent in establishment of habitat objectives is the need to develop population goals for forest dependent wildlife species. There are a number of factors, habitat being but one, which interact to control the number of individuals of a species found within a given area. In general however, long term population trends should follow changes in habitat availability. Forest-wildlife population goals must consider the identified demands of user groups as well as expected changes in habitat availability due to both natural and man-made changes to the forest. Deer and marten have been selected as the first species for which population goals will be established.

WHITE-TAILED DEER

Habitat / Population Objectives

The DNRE Big Game Program is developing an antlerless deer permit harvest system for implementation in 1990. The management system will set deer population (harvest) goals by Wildlife Management Zone, taking into account factors such as public demand, population status and identified habitat trends. A part of this system is the requirement for accurate assessment of deer population levels and status with respect to the ability of the land area to support deer (the relationship between habitat and supportable wildlife populations). The DNRE Big Game Program's objective for white-tailed deer is to maintain a population which will support current hunter harvest levels.

The Forest Land Habitat Program is working with Big Game to produce deer population estimates by Wildlife Management Zone for use in assessing the current status of deer populations. Statistical relationships between habitat and number of deer will not be available by the fall of 1990 for preparation of habitat objectives for the 1992 forest management plans. Habitat objectives will be established based on the assumption that the amount of habitat currently present is required to maintain current population levels.

Forest conditions that supply the four habitat components of white-tailed deer; thermal cover, hiding cover, winter food (browse) and summer food (forage) were described in terms of

Forest Development Survey attributes. Current forest management strategy is expected to supply all components into the future except thermal cover. Therefore efforts have been directed at determining thermal cover habitat objectives and management strategies for supplying this habitat type.

It is recognized that white-tailed deer at the northern extent of their range seek shelter from cold temperatures and deep snow during winter months, and it is assumed that without shelter habitat (thermal cover) the ability of an area to support deer will be near zero. Shelter is supplied by mature to over-mature softwood dominated forest stands. Deer tend to seek shelter stands which have southerly aspects and are located along watercourses. Deer are relatively consistent in the areas they select for winter shelter from year to year. These areas are known as deer wintering areas (DWA). The ability of deer to relocate to new areas given that their traditional DWA has lost its shelter qualities is not well understood and requires investigation. It is this reasoning that has lead to the development of the "Proposed Deer Wintering Area Management Strategy for Crown Timber Licenses in the Context of the 25 Year Forest Management Plan" outlined below.

Proposed Deer Wintering Area Management Strategy

Rationale. The New Brunswick Crown Lands and Forests Act (1982) states that Crown Land will be managed to provide habitat for the maintenance of fish and wildlife populations. The objective for deer wintering habitat to be used in the preparation of the 1992 twenty-five year forest management plan for each Crown Timber License is: to manage the forest to provide shelter habitat in quantity and quality at least equal in amount to levels currently identified by DNRE. The strategy proposed below provides the framework for ensuring that deer wintering habitat objectives are incorporated into the 25 year forest management plan for each License.

Under the current forest management planning system for Crown Lands, maps outlining the locations of known DWAs are provided to the Licensees by the Regional biologists. This information is used by the Licensee during management plan development. Harvest blocks located within or adjacent to identified DWAs may be modified by DNRE Regional staff so that timber harvesting will benefit deer. Due to intensive pressure on the Crown forest to produce wood fibre, existing DWAs are in danger of becoming islands of mature softwood, particularly as they are currently being managed without objectives for long term sustainability. The intent of the proposed strategy is to quantify an objective for DWA habitat (specifically shelter habitat) which is spatially referenced. That objective will be incorporated by the Licensee into the 25 year forest management plan and the determination of the annual allowable cut (AAC) for

the License.

Strategy Outline

1. Identify existing known deer wintering areas (DWA) within the provincial forest development survey (FDS) data base.

2. Quantify the amount of shelter habitat within DWAs and set this amount as a present objective for which to manage.

3. Identify deer wintering area management units (DWAMU) around existing DWAs in which the present amount of shelter habitat can be maintained over time.

4. Where DWAMUs cannot produce a sustainable amount of shelter habitat, the option will exist to identify new DWAMUs in areas not currently identified as DWA.

5. A WILD series habitat supply analysis model (See: Status Of HSA Development) will be used to determine timber harvest levels within the DWAMUs which will ensure a sustainable supply of shelter habitat, both at the Timber License level and for individual DWAMUs. These harvest levels will be incorporated into the Licensees wood supply.

6. Prepare timber harvesting and silviculture guidelines for DWAMUs in consultation with the Licensees.

7. Develop a system for updating the DWAMU data base (i.e., locating and incorporating new areas, removing unused areas, updating deer use patterns and forest condition information for existing areas). This will involve modifying the existing system.

Steps 1 and 2 will involve Program and DNRE regional staff. Steps 3 through 7 will involve Program, DNRE regional and Licensee staff.

Strategy Implementation. The locations of all identified DWAs on Crown Timber Licenses have been obtained from DNRE regional staff. Step 1 has been completed for 4 of 10 Timber Licenses and the remaining Licenses should be completed within a few weeks. A preliminary analysis of the Upper Miramichi Crown Timber License (License 4)(350 000 ha of softwood (SW) forest) indicates that 16 858 ha (4.8 % of SW forest) is identified as DWA (Table 1). Of the area identified as DWA, approximately 12 000 ha (70%) is estimated to be providing shelter habitat (immature to overmature SW). Based on this preliminary analysis the DWA shelter habitat objective for the License 4 forest management plan would be that no less than 12 000 ha of habitat be provided on a sustained basis. The unbalanced age class structure of the SW forest within identified DWAs on License 4

(<3% in regenerating and young SW) will require that additional areas be identified within the DWAMUs that contain younger SW stands to replace existing shelter habitat in the future.

MARTEN

Habitat / Population Objectives

A strategy for establishing habitat/population goals for marten is currently being developed. The Upper Miramichi Crown Timber License (350 000 ha of SW forest) was chosen as a test area for strategy development. Fur harvest data, which can be used to generate current population estimates by Wildlife Management Unit and Timber License, are limited. The current strategy is therefore to use the marten habitat model (See: Habitat Relationships Definitions) to generate suitable objectives. The model was used to assess future habitat supply for marten on the Upper Miramichi Crown Timber License. Inputs to the model were current (1987) forest structure and proposed forest harvest scenario as detailed in the 1987 Forest Management Plan for the license. Model output was carrying capacity of the license for marten, expressed as number of marten. Carrying capacity was assumed to equal 0.8 and 0.4 individuals/km^2 for habitat types 1 and 2, respectively (see Appendix 2 for descriptions of habitat types). Carrying capacity for the license was projected to decline from 1906 marten in 1987 to 1015 marten over the course of the present 25 year forest management plan. Longer term timber harvest projections indicate that marten carrying capacity will further decline to 234 by the year 2067 (Figure 1).

The first step towards establishing a habitat goal for marten will be to determine the range of possible goals. The harvest sequence for the management plan was determined by the wood supply model using the "rule" that loss of softwood volume due to stand decadence be minimized. By changing the rule to one that minimizes loss of marten habitat, the sustainable supply of habitat, and hence an upper bound to the goal, can be calculated. The lower bound will be defined as the amount of habitat needed to sustain a viable population. A habitat goal will be defined for the license as a proportion of the sustainable habitat. It will vary through time as the sustainable level varies but will not be allowed to go below the lower bound. An advantage of defining the goal as a proportion of a sustainable level is that the trade-offs, in terms of wood supply, are explicit.

Table 1. Preliminary analysis of forest conditions within Upper Miramichi Crown Timber License 4 (350 000 ha SW forest) deer wintering areas (16 858 ha).

FOREST UNIT	MATURITY (AREA IN HECTARES) REGENERATING ha	%	YOUNG IMMATURE ha	%	OLD IMMATURE ha	%	MATURE ha	%	OVERMATURE ha	%	TOTAL ha	%
SPBF	62	0.3	82	0.5	1467	8.7	4663	27.7	209	1.2	6473	38.4
BFSP	51	0.3	28	0.2	149	0.9	3077	18.3	64	0.4	3369	20.0
PINE	0	0.0	0	0.0	90	0.5	61	0.4	27	0.2	178	1.1
PSSP	0	0.0	0	0.0	0	0.0	85	0.5	95	0.6	180	1.1
OTSW	0	0.0	0	0.0	9	0.1	699	4.1	314	1.9	1022	6.1
SPTH	7	0.0	18	0.1	154	0.9	721	4.3	8	0.0	908	5.4
SPIH	0	0.0	3	0.0	38	0.2	192	1.1	3	0.0	236	1.4
BFTH	1	0.0	17	0.1	40	0.2	386	2.3	2	0.0	446	2.6
BFIH	21	0.1	20	0.1	0	0.0	175	1.0	0	0.0	216	1.3
THSP	5	0.0	39	0.2	77	0.5	391	2.3	9	0.1	521	3.1
IHSP	0	0.0	10	0.1	79	0.5	234	1.4	0	0.0	323	1.9
THBF	0	0.0	8	0.0	59	0.3	135	0.8	0	0.0	202	1.2
IHBF	14	0.1	120	0.7	0	0.0	88	0.5	18	0.1	240	1.4
IOHW	84	0.5	188	1.1	87	0.5	243	1.4	0	0.0	602	3.6
THIH	0	0.0	6	0.0	10	0.1	34	0.2	0	0.0	50	0.3
INHW	123	0.7	98	0.6	214	1.3	180	1.1	116	0.7	729	4.3
IHTH	26	0.2	13	0.1	9	0.1	5	0.0	0	0.0	53	0.3
PC	0	0.0	0	0.0	0	0.0	0	0.0	14	0.1	14	0.1
TOTAL	384	2.3	648	3.8	2462	14.7	11369	67.4	879	5.2	15762	93.5

	ha	%
PLANTATIONS	25	0.1
CUT-OVERS	348	2.1
BURNS	0	0.0
W,F and AC	22	0.1
NON-FOREST	12	0.1
FEDERAL LAND	0	0.0
BOGGY (AW,WL,NP)	689	4.1
WATER	0	0.0
GRAND TOTAL	16858	100.0

current shelter habitat = 12 000 ha

future shelter habitat = 301 ha

Note: 1. There may be slight inaccuracies due to rounding.
2. Data from DNR forest cover GIS database.
3. Forest Unit was given by FUNA; Maturity by P1D6.
4. PC is Partial Cut.
5. W is Windthrow; F is Old Field; AC is Alders on Cut.
6. Non-Forest is AG,GP,OC,RD,RO,RR and TM.

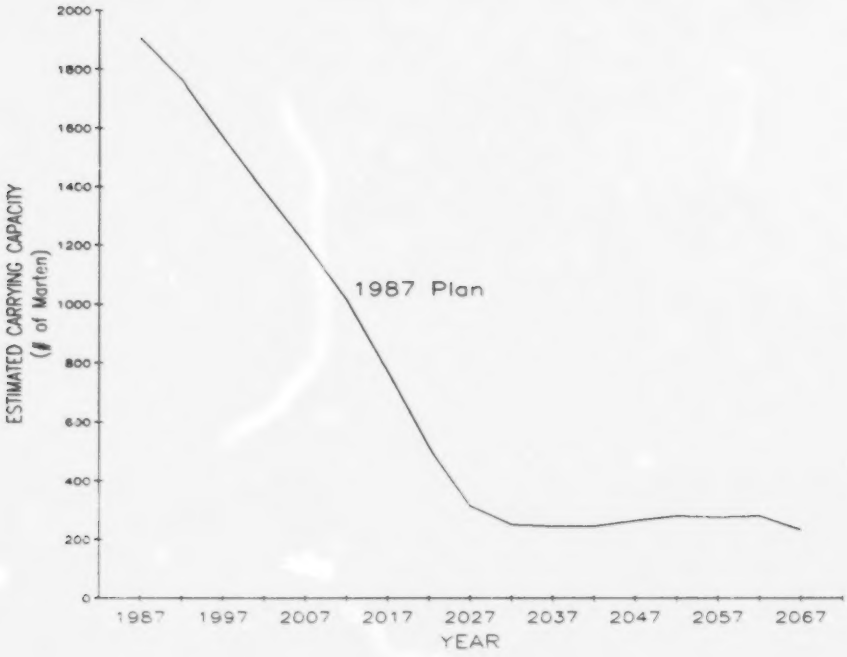


Figure 1. Projected carrying capacity for marten on the Upper Miramichi Crown Timber License based on 1987 Management Plan.

WILDLIFE TECHNICAL COMMITTEE

The Wildlife Technical committee acts as a steering group for the Forest Land Habitat Program. It is composed of representatives from the forest industry (Licensees), the University of New Brunswick, and the federal and provincial governments (Appendix 3). The committee meets in spring and fall. During the April 1989 meeting the results of the Green River Lakes Habitat Supply Analysis Project (Appendix 4) were presented and discussed. The Green River Lakes HSA Project was a precursor to the proposed DWA management strategy outlined previously in this report. On 12 October the proposed DWA management strategy and the preliminary marten habitat management strategy were presented for discussion. The committee was also updated on the other components of the project discussed in this report. The next scheduled meeting of the Wildlife Technical Committee will be in April 1990 however a winter (1990) meeting may be scheduled if deemed necessary.

3. DEVELOPMENT OF HABITAT SUPPLY ANALYSIS PROCEDURES

STATUS OF HSA DEVELOPMENT

Habitat supply analysis (HSA) programs based on the FORMAN wood supply analysis model (program series name WILD) have been used on a trial basis for computing habitat supply for white-tailed deer and american marten. When applied at a timber license scale, these non-spatial HSA programs present a biased habitat supply picture for those species where spatial requirements (adjacency of habitat components, minimum habitat patch size) are important. The problem with strata-based approaches (such as the WILD series) is that spatial definition is lost. To account for spatial availability of habitat, development of a computer program called the "Stand Projector" has been initiated. The intent of this program is to forecast and track individual stand development so that spatial habitat availability can be computed. Another benefit of the stand projector will be the separation of the forest succession model from the habitat relationships models, so that the forest picture is consistent.

Specific habitat supply analysis computer programs have been written for white-tailed deer and american marten HSA. For white-tailed deer HSA, a deer habitat suitability index (HSI) model was programmed and run on several forest cover map sheets to compute time 0 habitat. Currently, programs are being written to assist in defining deer wintering area management zones. For marten, the license 4 marten HSA was rerun using an updated habitat model. As well, two maps were produced to depict, at a 1:50 000 scale, time 0 marten habitat and all cuts that had taken place by year 25. The intent of this map production was to examine spatial distribution of marten habitat.

Buffer Strip Research Project.

This project, which was partly funded by the Forest Land Habitat Project (and discussed in previous progress reports), was completed, and a report was received in the form of a M.Sc.Forestry thesis. The project demonstrated the feasibility of using cartographic modelling procedures to devise a uniform method of calculating riparian buffer strip widths. However, the results are not immediately applicable, as much of the necessary data does not exist in digital form. Moreover, as it was a demonstration project, the sub-component models, such as the hiding cover model, were not refined to the point of providing useful output. As well, the demonstration system was not developed on the DNRE computer system. Currently another graduate student is attempting to implement this system on the DNRE minicomputer. Further application of this work will have to await the availability of the required digital data.

Timber Harvest Block Sequencing Research Project.

This project, described in the March 1989 progress report, has been completed. A copy of the computer program and User's Guide and a report in the form of a M.Sc.Forestry thesis has been received. This program will allow spatially-feasible scheduling of harvest blocks, differentiated by habitat type.

4. PUBLIC AWARENESS

Through the summer and early fall members of the Forest Land Habitat Program have presented talks to a number of interest groups promoting support for wildlife habitat management on public lands. The program plans to increase its efforts in this area as specific management strategies and preliminary habitat objectives are developed.

NEW BRUNSWICK FOREST WILDLIFE HABITAT PROGRAM

BUDGET EXPENDITURES

APRIL 1, 1989 - OCTOBER 1, 1989

ACTIVITY	CONTRIBUTOR D.N.R.E.	W.H.C.
Salaries and Benefits	80 875.00	55 809.00
Travel and Activity Expenses	814.00	893.00
Vehicles and Equipment	2 140.00	11.00
Professional Services, Materials and Supplies	2 254.00	1 996.00
Deer Wintering Area Aerial Survey	264.00	--------
Computer Hardware, Software and Support	6 624.00	135.00
TOTAL	92 971.00	58 844.00

GRAND TOTAL = D.N.R.E. + W.H.C.

= 92 971.00 + 58 844.00 = 151 815.00

APPENDICES

APPENDIX 1.

DESCRIPTION OF THE FOREST DEVELOPMENT SURVEY (FDS) VARIABLES FOREST UNIT AND DEVELOPMENT STAGE.

FDS VARIABLES

Forest Unit (FU)

SPBF	spruce-balsam fir	(SP component includes red, black and white spruce)
BFSP	balsam fir-spruce	
SPIH	spruce-intolerant hardwood	(IH component is primarily aspen and white birch)
IHSP	intolerant hardwood-spruce	
SPTH	spruce-tolerant hardwood	(TH component is primarily sugar and red maple, beech and yellow birch)
THSP	tolerant hardwood-spruce	
BFIH	balsam fir-intolerant hardwood	
IHBF	intolerant hardwood-balsam fir	
BFTH	balsam fir-tolerant hardwood	
THBF	tolerant hardwood-balsam fir	
OTSW	other softwood	(OTSW is primarily eastern white cedar)
PINE	pine	(PINE is primarily jack pine)
INHW	intolerant hardwood	
TOHW	tolerant hardwood	
IHTH	intolerant-tolerant hardwood	
THIH	tolerant-intolerant hardwood	

Development Stage (DS)

REGENERATING (R)	Stands where tree height is approximately 3 metres.
YOUNG (Y)	Stands that are accumulating wood volume at a rapid rate.
IMMATURE (I)	Stands that are still accumulating volume at a reasonable rate but that are older than Y stands and have not yet reached maturity.
MATURE (M)	Stands that are no longer accumulating volume: volume loss due to tree mortality approximately equals volume growth of remaining trees.
OVERMATURE (O)	Stands that are losing volume at a rapid rate: volume loss due to tree mortality exceeds volume growth of remaining trees.

APPENDIX 2.

MARTEN HABITAT MODEL

MARTEN HABITAT MODEL

The intent is to present a marten (Martes americana) habitat model suitable for use within the context of forest management planning in New Brunswick. The document is divided into four sections, dealing respectively with marten habitat requirements (literature synthesis), habitat data available for New Brunswick, proposed habitat relationships, and population densities (literature synthesis). Habitat interspersion requirements, though an important component of habitat supply management, are not considered herein.

HABITAT REQUIREMENTS

Habitat use by marten is well documented; the general ecology of the species is relatively well understood. Few authors, however, have attempted to describe how changing forest structure (succession) affects suitability of habitat for marten over time. In general, marten habitat consists of mature softwood or mixedwood forest with a high degree of crown closure and a high incidence of both standing dead trees and windfall (Marshall 1951, de Vos 1952, Francis and Stephenson 1972, Koehler and Hornocker 1977, Soutiere 1979, Bateman 1980, 1982, Steventon and Major 1982, Strickland and Douglas 1987, Taylor and Abrey 1982, Raine 1983, Spencer et al. 1983, Allen 1984, Wynne and Sherburne 1984, Ritter 1985, Snyder and Bissonette 1987, Thompson 1988, Buskirk et al. 1989). Important life requisites for marten are: den sites, winter thermal cover, escape cover, and food.

Den Sites

Marten use existing cavities in large snags and logs as den sites (Spencer 1981, Martin and Barrett 1983, Allen et al. 1984, Wynne and Sherburne 1984). Den trees in Maine were 40-70 cm in diameter (dbh) (Wynne and Sherburne 1984).

Winter Thermal Cover

Marten have short fur and a high surface-area-to-volume ratio and are therefore not well adapted to severe cold. In response to low temperatures, marten coordinated the depression of body temperature, the use of protected resting sites and the length of resting periods as means of energy management (Buskirk et al. 1988). Marten preference for subnivean winter resting sites associated with coarse woody debris, such as logs, stumps and snags, has been documented for Maine (Steventon and Major 1982), south-central Alaska (Buskirk 1984), Sierra Nevada, California (Spencer 1987) and the central Rocky Mountains, Wyoming (Buskirk et al. 1989).

Escape Cover

Marten are preyed upon by coyote (Canis latrans), fisher (Martes pennanti), red fox (Vulpes vulpes), lynx (Lynx canadensis) and great horned owls (Bubo virginianus); escape from

predators is achieved primarily by climbing trees (Strickland and Douglas 1987). Detection of marten by mammalian predators is likely reduced where ground vegetation is dense; detection by avian predators is likely reduced where overstory crown closure is high.

Marten use resting sites in summer. The criteria for selection of resting sites likely include the ability of the site to provide security. Most summer resting sites in Maine were 3-10 m above the ground in crowns of coniferous trees (Steventon and Major 1982, Wynne and Sherburne 1984). Most summer resting sites in the Sierra Nevada, California were also in live coniferous trees, although snags were preferentially selected (Spencer 1987).

Food

The ability of a forest to supply food for marten depends on both the abundance and the availability of small mammals.

Abundance. Microtine rodents are the most important source of food for marten (Cowan and Mackay 1950, Lensink et al. 1955, Quick 1955, Francis and Stephenson 1972, Bateman 1982a,b, Douglass et al. 1983, Spencer et al. 1983, Zielinski et al. 1983, Buskirk 1984, Hargis and McCullough 1984, Thompson 1988); the most common coniferous forest-dwelling microtine in New Brunswick is the red-backed vole (Clethrionomys gapperi) (Dilworth 1984, also see New Brunswick Habitat Data section below). Many microtine populations fluctuate periodically in size (e.g., Krebs et al. 1969); food abundance for marten is therefore only partly a function of habitat. Other important food sources for marten were snowshoe hares (Lepus americanus), shrews (Soricidae) and birds in Newfoundland (Bateman 1982b) and deer mice (Peromyscus maniculatus), shrews and berries in Ontario (Thompson 1988).

Habitat preferences of red-backed voles are cool moist (not wet) coniferous or mixed forests (Kirkland and Griffin 1974, Vickery 1981, DeGraff and Rudis 1986). They are generally associated with forests with little ground vegetation (Gunderson 1959) but heavy mid-canopy (Vickery 1981). Red-backed vole abundance did not differ among recently (1-3 years) clearcut, sapling and mature spruce-fir forests in Maine (Monthey and Soutiere 1985). In contrast, red-backed vole abundance declined sharply after clearcutting in black spruce forests in northern Ontario (Martell 1983a,b).

Availability. Marten use leaning trees, fallen branches and upturned roots that protrude from the snow to gain access to prey in subnivean spaces (Marshall 1951, Francis and Stephenson 1972, Steventon and Major 1982, Allen 1984, Hargis and McCullough 1984, Allen 1985). Availability of small mammals in winter may therefore be limited by amount of subnivean access. Access is likely restricted in open areas, deciduous forests and young

coniferous and mixed forests.

NEW BRUNSWICK HABITAT DATA

Pertinent data on forest structure were available from the Timber Management Branch Permanent Sampling Program (PSP) and from the Fish and Wildlife Branch marten and deer wintering area (DWA) studies. They were analyzed to determine whether occurrence of snags or downfall differed among various forest classes (forest unit (FU)/development stage (DS) combinations).

Snag abundances were available from PSP data for SPBF/M, SPBF/O, BFSP/M and BFSP/O forest classes (n = 128, 26, 65 and 14 stands, respectively). Pair-wise comparisons among forest classes indicated that abundance of snag trees with diameters at breast height ≥30 cm was greater for BFSP/O than for SPBF/O ($P = 0.08$) but did not differ between BFSP/M and BFSP/O ($P = 0.21$), between SPBF/M and SPBF/O ($P = 0.55$) or between SPBF/M and BFSP/M ($P = 0.44$) (Mann-Whitney tests, Zar 1984:139).

Data on presence or absence of downfall were available from the marten study vegetation data for SPBF/I, SPBF/M and BFSP/M forest classes (n = 19 plots from 4 stands, 22 plots from 7 stands and 111 plots from 26 stands, respectively). Similar data were available from the Simpson's Field DWA study for SPBF/M, BFSP/M, BFSP/O and OTSW/O (eastern white cedar-dominated) forest classes (n = 68 plots in 5 stands, 92 plots in 7 stands, 76 plots in 6 stands and 152 plots in 11 stands, respectively). Inference to the forest class level may be inappropriate from either data set because plot locations were not independent and hence comprised a form of pseudoreplication (Hurlbert 1984). Results of analyses are given nonetheless. For marten vegetation data set, proportions of sample plots with downfall present did not differ between SPBF/I and SPBF/M ($P = 0.96$) or between SPBF/M and BFSP/M ($P = 0.74$) (G-tests, Zar 1984:71). For DWA data set, proportions of sample plots with downfall were greater for OTSW/O than for all others ($P < 0.001$) but did not differ between SPBF/M and BFSP/M ($P = 0.16$) or between SPBF/M and SPBF/O ($P = 0.69$) (G-tests, Zar 1984:71).

Small mammals were snap-trapped on the Nepisiguit River drainage in north-central New Brunswick during the autumns of 1987 and 1988. Data were available from 5580 trap nights (years combined); capture rate was 0.25/trap night. Seventy five percent of trap nights were in balsam fir- or spruce-dominated stands in the immature to overmature development stages. Red-backed voles, deer mice (*Peromyscus maniculatus*) and masked shrews (*Sorex cinerus*) comprised 93%, 4% and 2% of the catch by number, respectively.

MODEL

This model is similar in structure to those developed by the USDI Fish and Wildlife Service as part of their Habitat Suitability Index series (USDI Fish and Wildlife Service 1980). Model output is an index value from 0.0 (unsuitable habitat) to 1.0 (most suitable habitat). Input to the model is forest structure, as defined by the variables forest unit (FU) and development stage (DS) of the New Brunswick Forest Development Survey (FDS).

FUs and DSs were ranked by ability to supply marten habitat. The following assumptions about forest structure (and hence habitat value) were made in assigning ranks:

1. The FU assigned to a stand indicates the two most common overstory tree species in that stand.

2. The DS assigned to a stand reflects the contribution of the primary component (first species in FU designation) to stand structure. However, the secondary component of a stand also contributes to its habitat value.

3. The softwood (SW) component of stands dominated by balsam fir (BF) does not differ structurally from the SW component of stands dominated by spruce (SP) with the same DS.

4. The hardwood (HW) component of stands dominated by intolerant hardwoods (IH) may differ structurally from the HW component of stands dominated by tolerant hardwoods (TH) with the same DS. Stands with an IH component likely yield more snags and downfall than do stands with a TH component. However, snags and downfall in stands with a TH component are likely more persistent than those in stands with an IH component.

As components of mixed stands, tree species are ranked as follows in their ability to supply marten habitat: BF=SP>IH=TH.

Ranking of forest units containing BF or SP by ability to supply marten habitat is:

1. BFSP, BFIH, BFTH, SPBF, SPIH, SPTH
2. IHBF, THBF, IHSP, THSP, PSSP

Ranking of forest units not containing SP or BF by ability to supply marten habitat is:

1. OTSW
2. PINE
3. INHW, TOHW, IHTH, THIH

Ranking of DSs by ability to supply marten habitat is:

1. OVERMATURE, MATURE
2. IMMATURE
3. YOUNG, REGENERATING, CUT

By combining rankings of DSs and FUs, an index to habitat suitability for marten is described as a function of forest class (FC) (Table 1, Figure 1).

POPULATION DENSITY

Adult marten exclude individuals of the same sex from their home ranges (Hawley and Newby 1957, Francis and Stephenson 1975, Ritter 1985). By assuming that all available habitat in an area is utilized by marten, a maximum density can be calculated for each sex (inverse of mean home range size). Within an area, marten density can vary with time; Thompson and Colgan (1988) reported that home range size increased, and density decreased, with a reduction in prey density.

Home range sizes for marten across their range were 2.5-15.6 km^2 and 0.7-4.3 km^2 for males and females, respectively (various authors; summarized by Allen et al. 1984, Ritter 1985, Strickland and Douglas 1987). For Maine, home range sizes were 5.6-9.9 km^2 and 2.0-2.9 km^2 for males and females, respectively (Steventon and Major 1982, Wynne and Sherburne 1984). Using the Maine home range sizes, calculated densities were 0.44-0.68 residents/km^2, males and females combined.

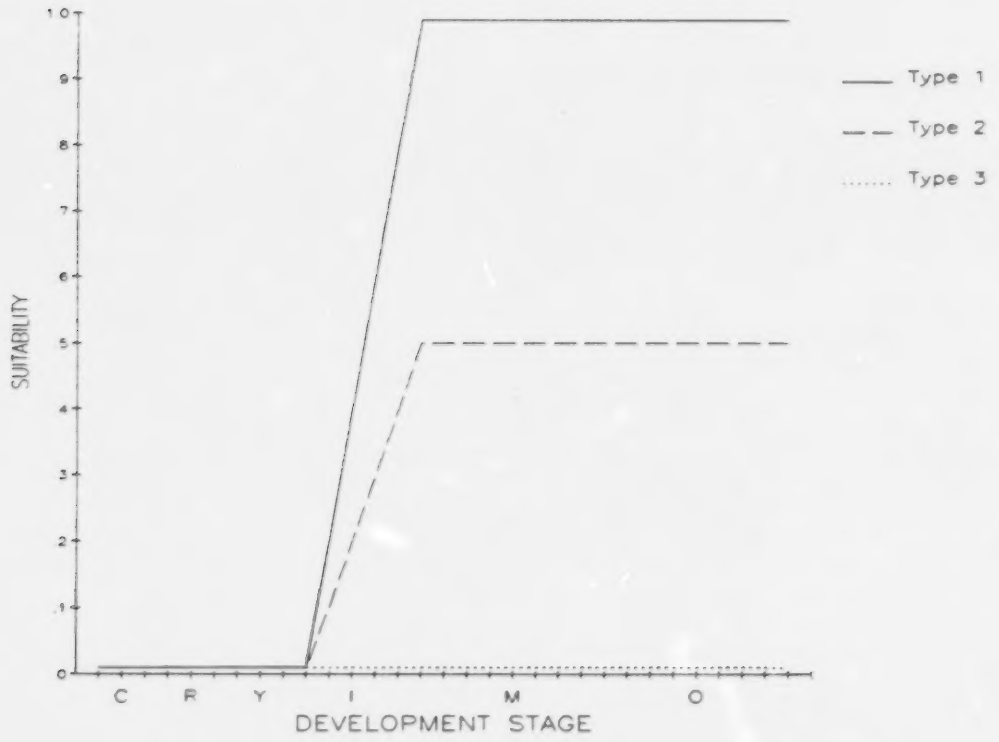
Density of marten in Glacier National Park, Montana was estimated to fluctuate from 0.19 to 0.69 residents/km^2 over a 2.5 year period (Hawley and Newby 1957). Francis and Stephenson (1975) estimated a density of 0.6 residents/km^2 for Algonquin Park, Ontario. Soutiere (1979) estimated a density of 1.22 residents/km^2 in what he considered good marten habitat in Maine. Bateman (1982b) considered 1.0 marten/km^2 a conservative estimate of carrying capacity of good habitat in national parks in the Maritime Provinces.

I assume a 1:1 (45^0), direct, linear relationship (origin at 0,0) between the calculated habitat suitability index value and potential marten density (carrying capacity). I equate an index value of 1.0 to a density of 0.8 ± 0.4.

Table 1. Index to habitat suitability for marten by forest class

Forest Type	Development Stage					
	C	R	Y	I	M	O
1	0.0	0.0	0.0	-	1.0	1.0
2	0.0	0.0	0.0	-	0.5	0.5
3	0.0	0.0	0.0	0.0	0.0	0.0

Type 1 = BFSP, BFIH, BFTH, SPBF, SPIH, SPTH, OTSW
Type 2 = IHBF, THBF, IHSP, THSP, PSSP, PINE
Type 3 = INHW, IHTH, THIH, TOHW



TYPE 1 = BFSP, BFIH, BFTH, SPBF, SPIH, SPTH, OTSW
TYPE 2 = IHBF, THBF, IHSP, THSP, PSSP, PINE
TYPE 3 = INHW, IHTH, THIH, TOHW

Figure 1. Index to habitat suitability for marten by forest class

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APPENDIX 3.

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APPENDIX 4.

GREEN RIVER LAKES

HABITAT SUPPLY ANALYSIS PROJECT

REPORT

GREEN RIVER LAKES PROJECT REPORT

DEER WINTERING AREA SHELTER HABITAT SUPPLY ANALYSIS

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N.B. Dept. of Natural Resources and Energy

October 5, 1989

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INTRODUCTION

In 1987 Fraser Inc. of Edmunston and the New Brunswick Dept. of Natural Resources and Energy (DNRE), Region 5, identified the portion of Fraser freehold surrounding First, Second and Third Lakes for special management consideration (Figure 1). An agreement in principle was established to cooperate in developing a timber management plan that would in addition to wood fibre production, take into account wildlife habitat and aesthetic values. In the fall of 1987 the Forest Lands Habitat Group of Fish and Wildlife Branch, DNRE, was requested to become involved in the project. For the Forest Land Habitat Group, the objective was to use habitat supply analysis (HSA) techniques to develop a timber harvest schedule that would create a sustainable supply of white-tailed deer (Odocoileus virginianus) winter shelter habitat (DWA) while providing a economic flow of wood products from the area. Additionally, the project was expected to point out strengths and weaknesses in current HSA techniques, and identify direction for future HSA development.

STUDY AREA

The study area was located in the northwest corner of New Brunswick within DNRE Administration Region 5, District 5-5 (Figure 1) encompassing 6300 hectares (ha) of which 630 ha is water. The area falls within the Gournamite Ecodistrict (Loukes, 1968) which is characterized by strongly rolling topography. First and Third Lakes sit at 221 and 244 metres respectively with hills rising to 365 to 455 metres within 0.75 to 1.5 kilometres of the lakes. Loukes (1968) described the soils of the district as rubbly silt loams derived from soft slates and argillites with a deep vertical cleavage. Bedrock is often near the surface, but so fractured that it is readily penetrated by tree roots.

Softwood dominated forest (softwood and softwood/hardwood) covers 67 % of the land area; hardwood dominated forest covered 22%. The remaining land area was covered by recent cutovers and plantations (7.5%) or non-forest condition (3.5%). Balsam fir (Abies balsamea) was the principal tree species in 87% of the softwood dominated forest. Eighty nine percent of the softwood dominated forest in the study area was mature (71%) or overmature (18%) (Figure 2). Little disturbance (i.e. timber harvesting, fire, etc.) has occurred within the study area over the previous 50 years. Timber harvesting outside the study area was concentrated to the south and southwest.

From stand attribute information available from Fraser forest inventory maps, 2700 ha of potential current winter cover (PCDWA) existed with an additional 500 ha in younger potential future winter shelter (PFDWA) (Figure 3) (See Methods for a description of potential deer winter area (PDWA), PCDWA & PFDWA). From winter aerial and ground survey information supplied by DNRE Region 5, 1933 ha were known to have been used by deer in previous years. Of the 1933 ha actively used, 465 ha did not have the photo-interpreted stand attributes, thought adequate to supply shelter for deer during severe winters.

Figure 1. Green River Lakes Study Area.

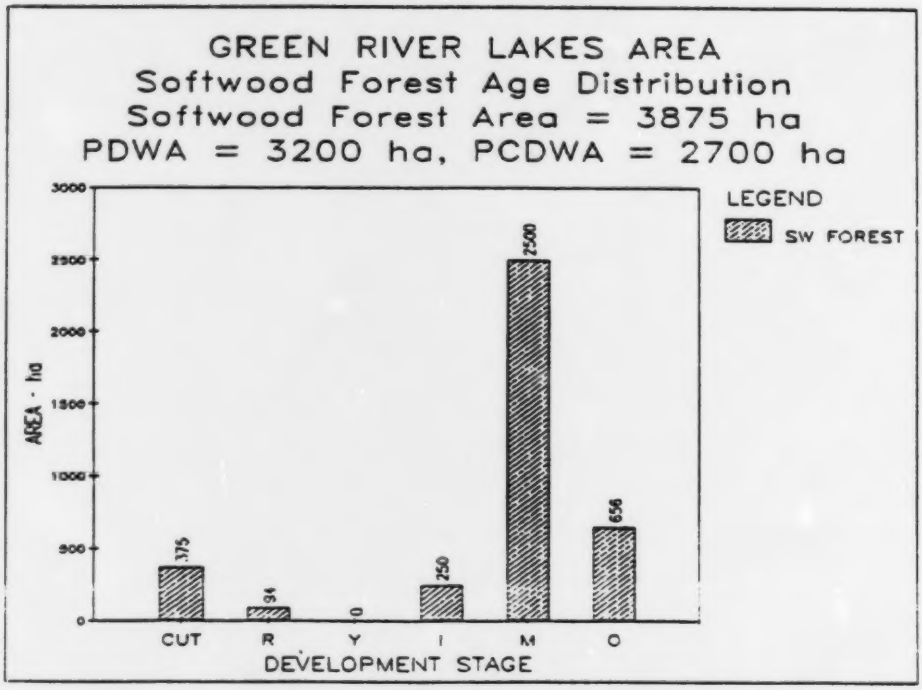

Figure 2. Softwood forest age distribution - Green River Lakes Study Area. PDWA = total potential deer wintering area, PCDWA = potential current DWA.

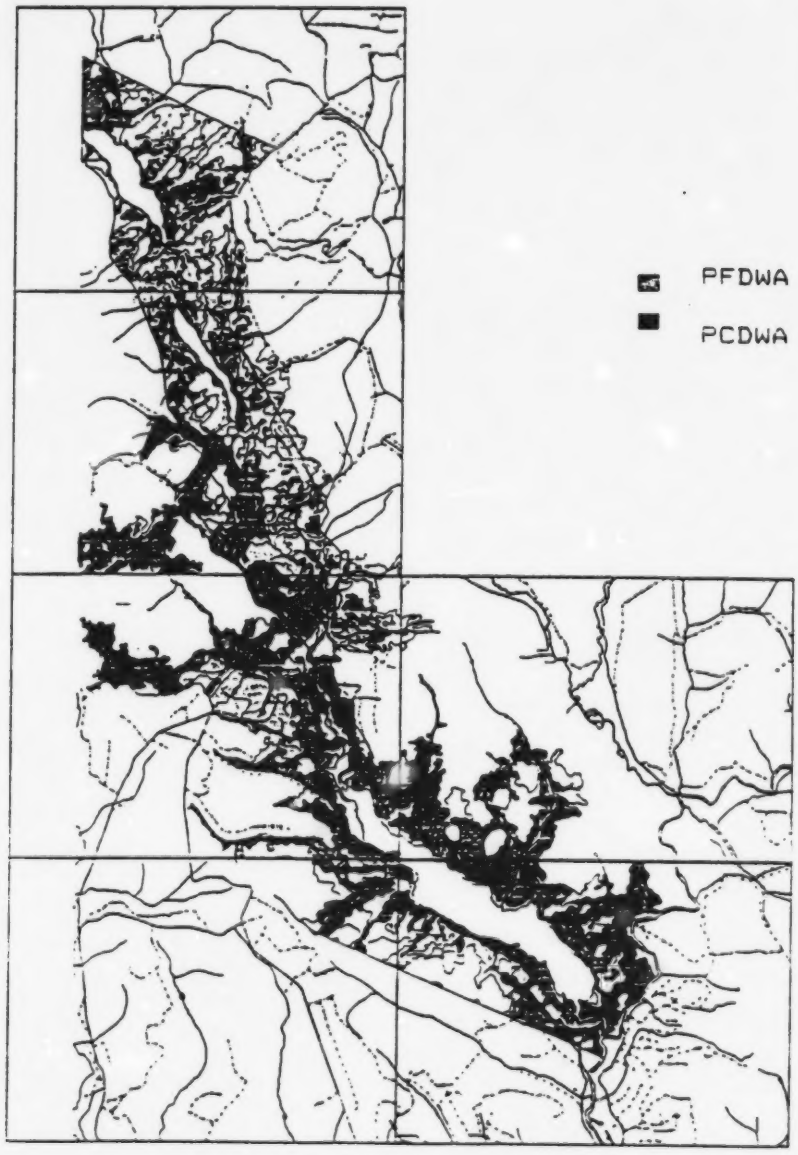

Figure 3. Potential deer wintering area (PDWA) based on forest stand attributes - Green River Lakes Study Area. PFDWA = potential future DWA, PCDWA = potential current DWA.

METHODS

STUDY AREA DESCRIPTION

The study area was outlined on 1:12500 N.B. forest covertype maps and all the forest stands within the area were listed. A work area on the DNRE Prime 550 Mini-computer was identified (HABITAT>GR_RIVER>INFO) and the photo interpreted attributes for all polygons in the study area were read into the work area in INFO format. An area summary was done based on general tree species composition (forest unit (FUNA)), development stage and crown closure. Their are 17 forest units which are used to group stands which have similar tree species composition based on photo-interpretation.

DETERMINATION OF POTENTIAL DEER WINTERING AREA

All stands were classified as either potential deer wintering area (PDWA) or non-PDWA based on stand attributes (species composition and crown closure) and known use by deer. Potential deer wintering area stands are stands which based on attributes, will at some time during their development be capable of supplying winter shelter for deer. Potential current DWA and PFDWA are differentiated based on stand development stage (PCDWA = immature, mature and overmature development stages; PFDWA = cut, regeneration and young development stages).

A description of what constitutes potential deer winter shelter habitat (PDWA) was defined and expressed in terms compatible with New Brunswick Forest Development Survey (FDS) (1987) stand descriptors. The FDS stand descriptors used to define PDWA were; forest unit (FUNA) and crown closure (CC).

Potential deer wintering area was defined based on information from the following DNRE publications; Forest Management Manual (1985), Deer Wintering Area Management For The Eighties (1982), Forestry Practices and Deer Habitat Management (1977). Potential Deer Wintering Area was described as softwood (forest units = SPBF, BFSP, OTSW, PSSP) or softwood/hardwood (forest units = SPTH, SPIH, BFTH, BFIH) forest units with crown closures greater-than-or-equal-to 50% and 70% respectively. If a stand had more than one development stage, the combined crown closure was used as long as the development stages were not more than 2 stages apart (eg. immature + overmature YES; young + overmature NO).

If a stand was known to be used by deer for shelter in winter (softwood dominated stands), it was considered PDWA, regardless of its crown closure.

HABITAT SUPPLY ANALYSIS

General

This project used a modified version (WILD2.6, Vietinghoff, 1988) of the FORMAN wood supply model (Wang, 1986) that monitors the amount of deer wintering area (DWA) habitat available over time under different timber harvest scenarios. Refer to the FORMAN Wood Supply User Manual (Wang,1986) for required background material. The model requires a **forest class file** and a **curve set file** to generate forecasts of timber and habitat availability. The model allows different harvest and silviculture levels as well as harvest priority rules to be specified on a year by year basis for an eighty year simulation period and reports on the condition of the forest at the end of each 5 year iteration or harvest period.

Forest Class File

All forest stands were assigned to one of 17 forest units (FUNA) based on species composition according to rules developed by Timber Management Branch, DNRE (1987). A **forest class group** is made up of stands with the same FUNA, development stage, crown closure and site type. A **forest class** has an assigned age and the class file indicates what yield curve set a class is presently following, the curve set it will follow after harvest, the curve set it would follow if planted and the priority it should receive for planting. Breakdown of forest class groups into forest classes is done using averages (forest class ages, post treatment response) obtained through sampling stands within a class group on a Timber License.

Stands were assigned to forest class groups by Fraser Inc.. A forest class file was generated using the stand age proportions Fraser Inc. established for their freehold lands. A planting priority of zero (no planting) was set for those SW forest classes which are capable of supplying DWA shelter habitat (file name - Classpp.grw). It was assumed that planted areas would be harvested prior to becoming DWA shelter habitat.

Not all stands were assigned a FUNA based on their dominant development stage (reason unknown). In order to better reflect actual forest conditions in the study area, a series of modifications were made to the original forest class file. A second forest class file (Cass2pp.grw) was generated by manually examining the stand list, and for all two age stands, setting the primary FUNA based on the dominant development stage and crown closure (Appendix 1). In cases where the primary FUNA or development stage were changed, stands were reassigned to a new forest class group. The new class groups were subdivided into forest classes based on Fraser's license level stand age averages.

The second forest class file was modified to produce a third forest class file (Class3pp.grw) by assigning stands individually to age groups within class groups. Ages were assigned based on the photo interpreted proportions of immature, mature and overmature spruce and balsam fir in the stand (Appendix 2). It was felt that assigning ages to stands individually would produce a more accurate representation of forest structure in the study area than would be the case using license level averages.

Curve Set File

The curve set file contains all the curves the different forest classes may follow. The curve sets used in this project have 4 separate curves. The curves have age as the independent variable and either softwood volume, hardwood volume, percent product, or a DWA-window value as the dependent variable. The **DWA-window** represents the time period during which a forest class has the potential to provide shelter habitat. Each forest class contains a broad range of stands, some of which do not satisfy the requirements for deer shelter. Therefore, the actual area of PDWA shelter available was determined by using the proportion of stands within a forest class that have been defined as PDWA. This value is known as the **PDWA proportion.**

Development of DWA Shelter Habitat Curves

DWA-window

The development stages or time frame during which PDWA forest classes can provide shelter habitat (DWA-window) were estimated based on information contained in the publications listed above (listed under, Determination of Potential Deer Wintering Area). For forest units that are considered PDWA, shelter habitat may be provided by development stages of immature (I), mature (M) and overmature (O). However, for HSA the actual DWA-window must be defined with specific ages. Stand attribute and age information from FDS sample stand plots located on License 10 were examined to assign specific ages to the DWA-windows (Table 1). The age to which a class could provide DWA shelter habitat, was determined to be the age beyond which the number of FDS sample stands meeting the crown closure requirements dropped noticeably (Note: no statistical analysis was used). A second DWA-window mode was added to BFSP curve sets (Table 1) to account for stands that are not harvested and regenerate naturally.

PDWA Proportions

Since not all stands within a PDWA forest class (curve set) have the crown closure required to be PDWA, the proportion of stands following a curve set that have the crown closure attributes which will allow them to provide shelter was determined. The proportion of area following a curve set that

Table 1. DWA-windows for PDWA curves - GR_Lakes Study Area.

CURVE	DWA WINDOW BY CURVE VERSION		
CURV	5R.S25	5R.S15	5R.S05
1. SPBF O L	70 - 120	70 - 130	70 - 140
2. SPBF M L	60 - 120	60 - 130	60 - 140
3. SPBF I L	50 - 120	50 - 130	50 - 140
4. SPBF O H	40 - 130	50 - 140	40 - 160
5. SPBF M H	40 - 130	50 - 140	40 - 160
6. SPBF I H	40 - 130	50 - 140	40 - 160
7. BFSP O A	50 - 100, 160	50 - 110, 160+	50 - 120, 170+
8. BFSP M A	40 - 100, 160	50 - 110, 160+	40 - 120, 170+
9. BFSP I A	40 - 100, 160	50 - 110, 160+	40 - 120, 170+
10. BFSP Y A	40 - 160, 160	50 - 110, 160+	40 - 120, 170+
11. OTSW O A	60 - 140	60 - 150	60 - 160
12. OTSW M A	60 - 140	60 - 150	60 - 160
15. BFHW O A	60 - 100	60 - 100	60 - 110
16. BFHW M A	60 - 100	60 - 100	60 - 110
17. BFHW I A	60 - 100	60 - 100	60 - 110
18. BFHW Y A	60 - 100	60 - 100	60 - 110
36. R1	45 - 100	45 - 110	50 - 120
38. R2	55 - 100	55 - 110	60 - 120
53. X	45 - 100	45 - 110	50 - 120
54. Y	55 - 100	55 - 110	60 - 120

could provide DWA shelter habitat was calculated by dividing the sum of the areas of stands with the required crown closures by the total area following the curve set (Table 2).

DWA Shelter Curves

For all curve sets associated with PDWA forest classes, a curve that provides the DWA-window and the proportion of the area in the class that is PDWA, was added so that DWA shelter habitat availability could be forecasted. For each DWA-window curve there is a 50 percent step-wise reduction in the proportion of area supplying DWA shelter habitat over the last 10 years of the window (Figure 4). A step-wise decline was used to reflect the natural variability in the way individual forest stands change over time. The rate at which the decline occurs was chosen arbitrarily.

Sensitivity Analysis

To test the effect an error in the width (time) of the DWA-window would have on DWA availability, the longevity of the DWA-window was adjusted by 10 year intervals and the resulting effects interpreted.

Habitat Supply Analysis

The program Wild2.6 was used to generate harvest and silviculture schedules that would result in a sustainable supply of DWA shelter habitat over the long term (80 years). Schedules were developed using each of the three forest class files for the whole study area and for just the area defined as PDWA. Spatial constraints with respect to size and location of harvest areas and buffer zones were not considered at this level of analysis.

TIMBER HARVEST SCHEDULING

Setting Harvest Priority

The harvest sequence file produced by Wild2.6 lists the order in which the harvest is taken by forest class and area (hectares). Using this information, along with a list of which stands are assigned to each forest class, stands to be harvested were assigned a harvest priority value of high (1), medium (2) or low priority (3). Forest covertype maps highlighting stands by harvest priority were produced to assess the spatial aspects of the proposed harvest schedules and provide a basis on which the actual harvest operations could be planned.

Table 2. Proportion of area following a curve set being PDWA.

Present Curve #	PDWA Area	Total Area	Proportion %
1	47	50	94
2	135	151	89
3	11	11	100
4	11	11	100
5	145	145	100
6	0	0	0
7	241	256	90
8	1586	1672	95
9	425	429	99
10	56	56	100
11	78	92	85
12	0	0	0
15	26	149	17
16	110	328	33
17	61	91	67
18	33	67	77
36*			100
38*			60
53*			100
54*			60

* Regeneration curves; no areas available to base proportions.

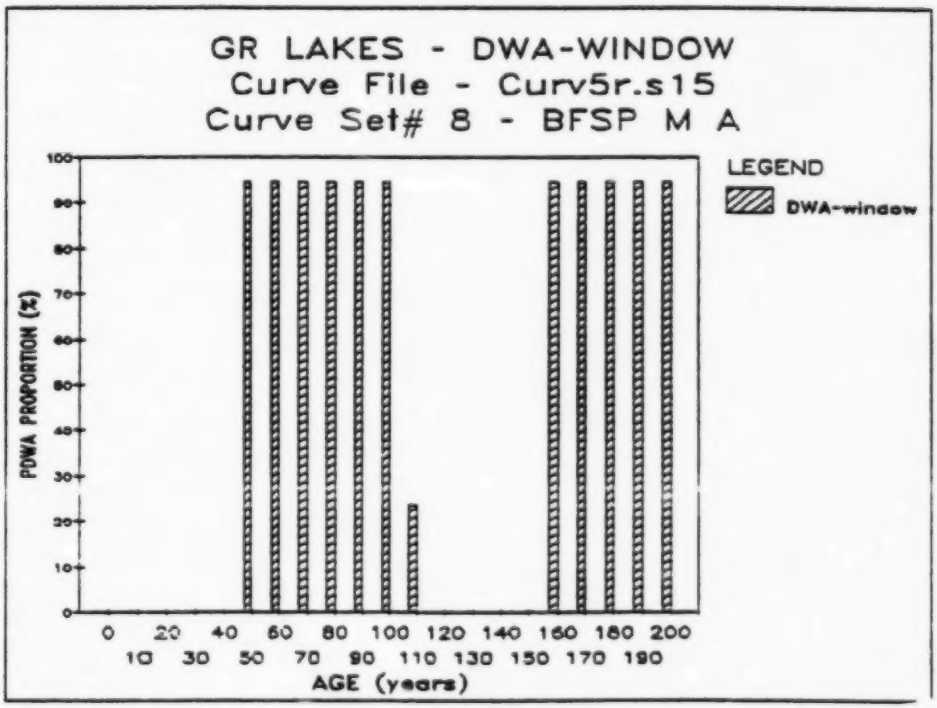

Figure 4. DWA-window component of the BFSP M A curve set (curve file - Curv5r.s15) indicating the developmental time frame during which shelter habitat is supplied by the area following this curve set. Ninety five percent of the area following this curve set is PDWA.

Operating Plan Development

The operating harvest plan will be developed by Fraser Inc. with input as required from DNRE Fish and Wildlife Branch and DNRE Region 5. The results of the HSA will be used to provide the frame work for developing the operating plan. In developing the operating plan, special consideration will be given to reducing direct impacts to the areas currently utilized by deer and to aesthetics. Based on the level, timing and location of harvest proposed in the plan, HSA will be used to assess the long term impacts of the operating plan on DWA shelter habitat.

RESULTS

HABITAT SUPPLY ANALYSIS

No Timber Harvest

Without timber harvesting, the amount of deer winter shelter habitat declined steadily from the present to year 45 with a large decline after year 45 (Figure 5). DWA shelter habitat shows an increase between years 71 and 75 as natural regeneration develops into shelter habitat.

With Timber Harvest

Sustainable Shelter Habitat

To create a sustainable supply of DWA shelter habitat within the study area over the next 80 years, intensive timber harvesting within the PDWA in the first 20 years is required (Figure 6)(Appendix 3). With intensive timber harvesting, a sustainable yield of shelter habitat is achieved beyond year 15. The sustainable level of DWA shelter habitat is between 1300 - 1600 hectares which is significantly lower than the present 2700 hectares. Reducing the timber harvest level during the first 20 years results in a higher level of shelter habitat for the first 35 years and a decline in the sustainable yield of shelter habitat beyond year 45 (Figure 7).

Harvest Priority Map

A harvest priority map of the Green River Lakes Area was produced from the harvest sequence file generated by the sustainable DWA shelter habitat HSA (Figure 8). The map does not acknowledge spatial constraints that would be applied to timber harvesting at the operational level.

Operating Plan Development

An operating plan for the Green River Lakes Study Area is currently being developed by Fraser Inc. As part of plan development, Fraser Inc. will carry out ground checks of areas prioritized for harvest to ensure harvest efforts are being directed to the areas at greatest risk to blowdown and budworm damage.

DWA WINDOW SENSITIVITY ANALYSIS

Decreasing the longevity of the DWA-window causes an earlier decline in shelter habitat (Figure 9), under a no harvest scenario. When the longevity through which balsam fir/spruce (BFSP) stands can provide shelter habitat is reduced to under 100 years, harvesting at any level in the initial periods cannot prevent a drastic decline in shelter habitat from occurring between years 35 and 40 years (Figure 10). Increasing the longevity of the DWA-window causes the decline in shelter habitat to occur later.

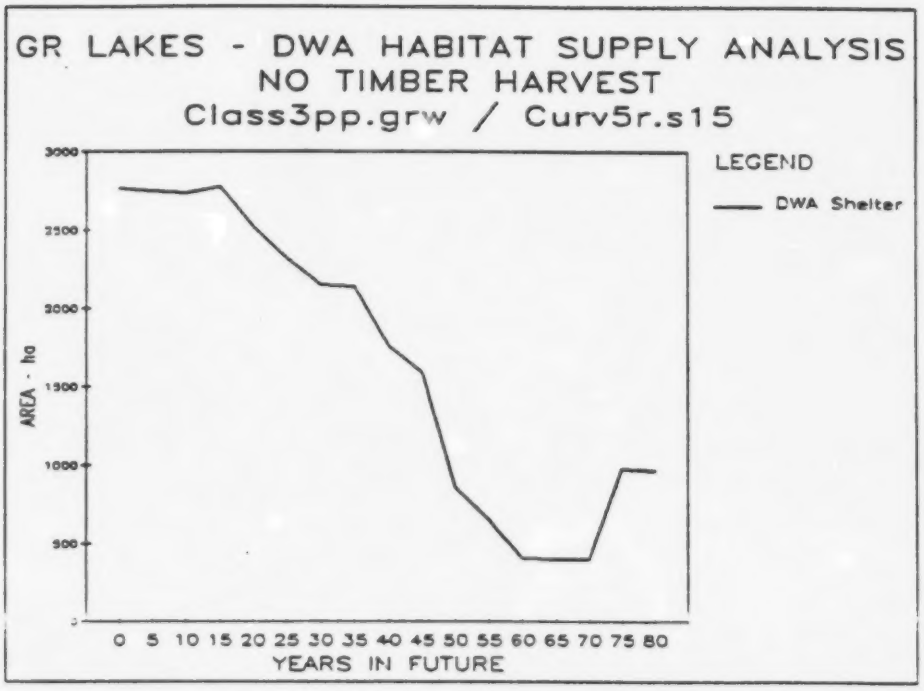

Figure 5. Deer wintering area shelter habitat response with no timber harvest - Green River Lakes Study Area.

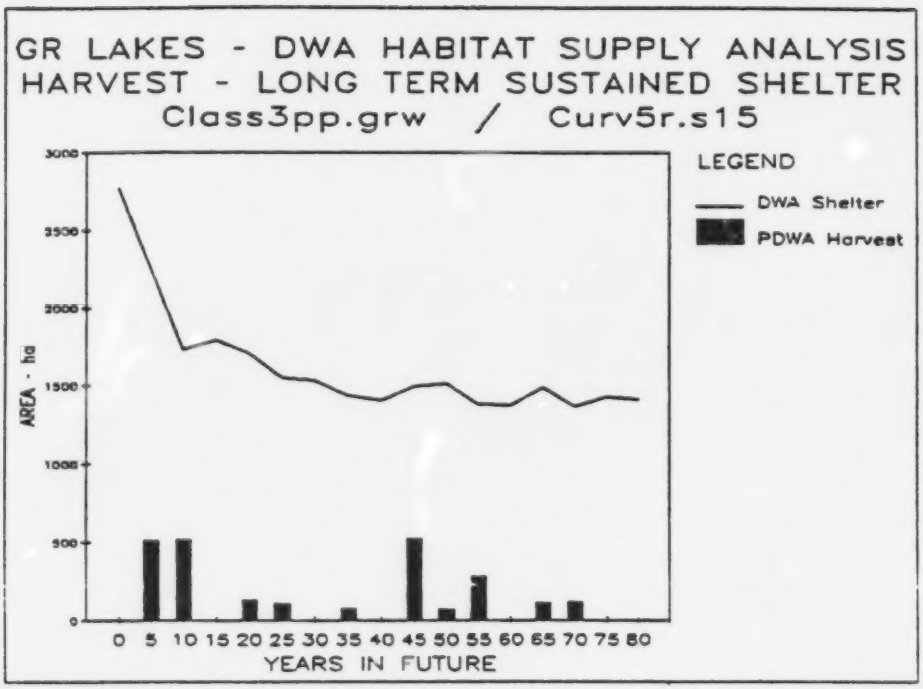

Figure 6. Sustainable deer wintering area shelter habitat with timber harvesting - Green River Lakes Study Area.

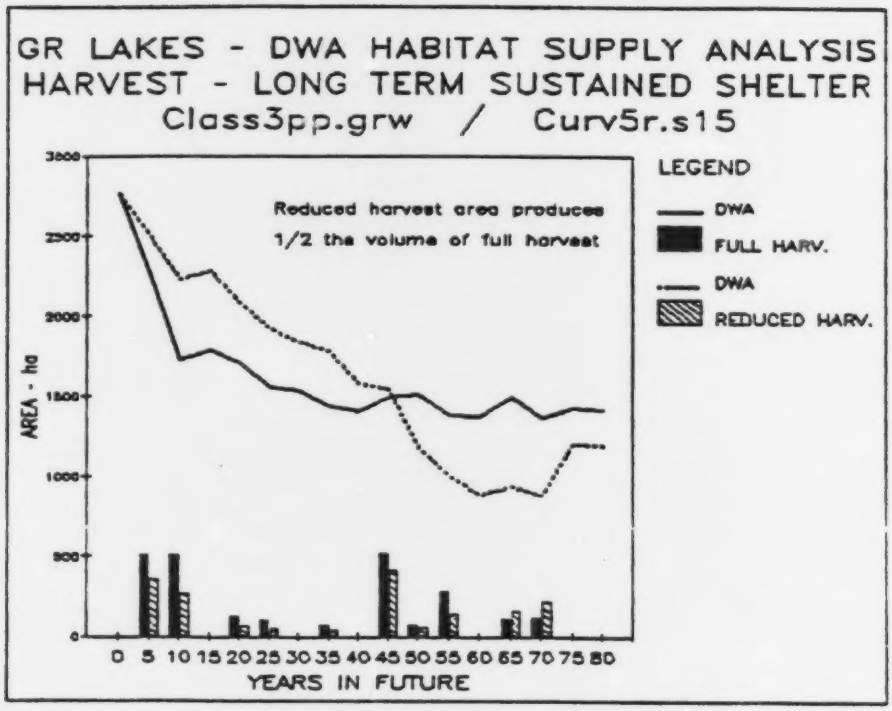

Figure 7. Deer wintering area shelter habitat response at 50 percent of sustained yield timber harvest level (Figure 5) - Green River Lakes Study Area.

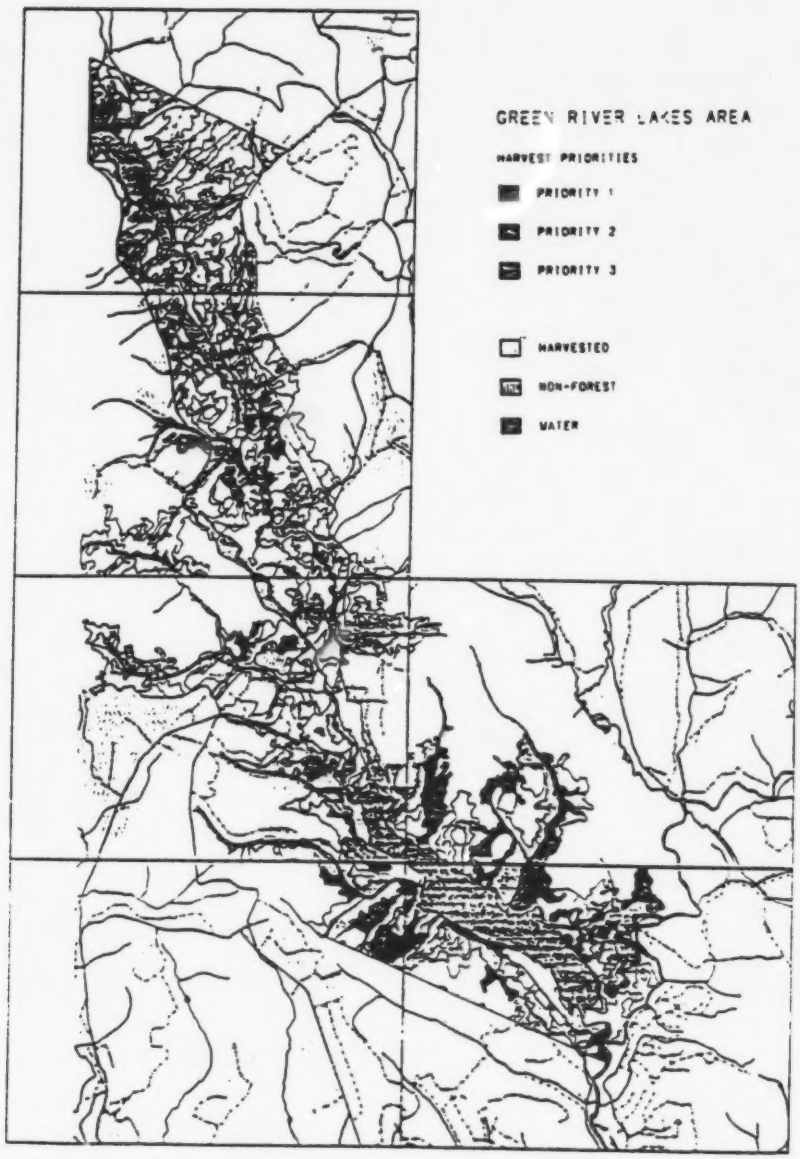

Figure 8. Timber harvest priority map for long term sustainable DWA shelter habitat - Green River Lakes Study Area.

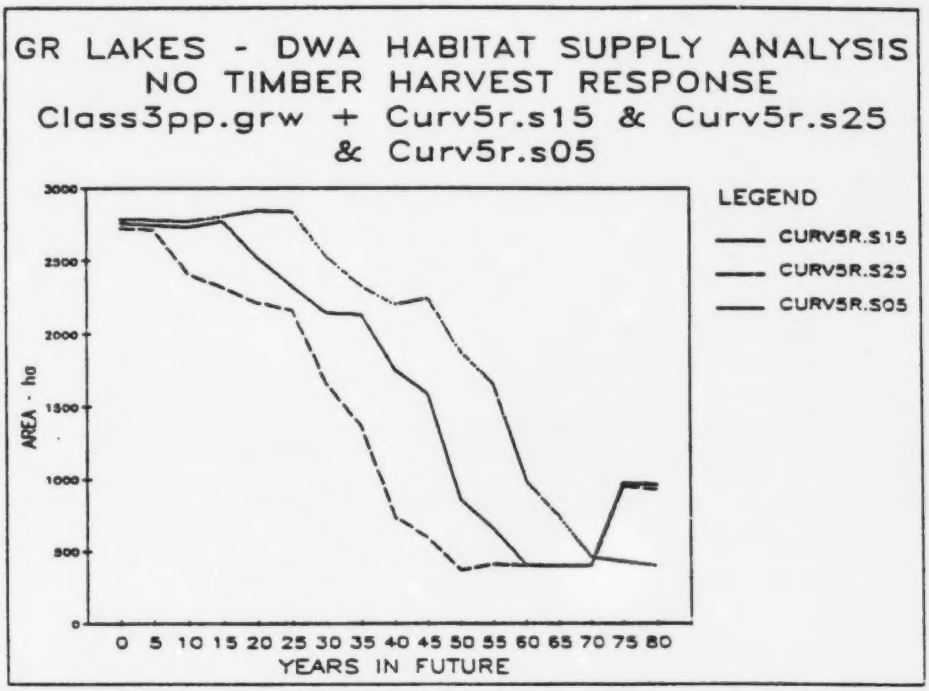

Figure 9. Deer wintering area shelter habitat response with a decrease in DWA-window longevity - Green River Lakes Study Area.

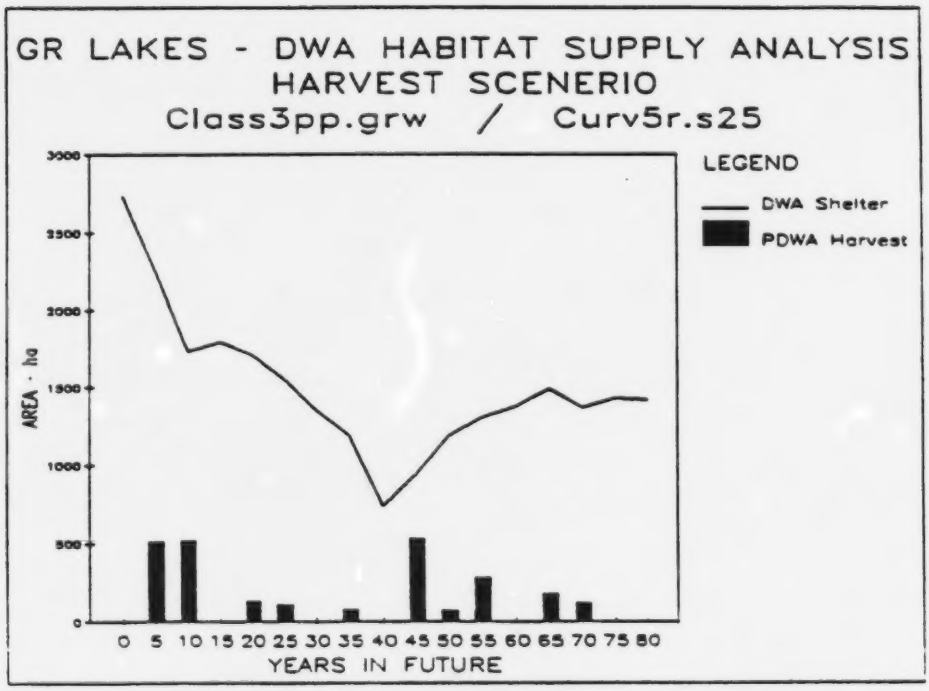

Figure 10. Deer wintering area shelter habitat response with timber harvest and reduced DWA-window longevity - Green River Lakes Study Area.

DISCUSSION

HABITAT SUPPLY ANALYSIS APPLICATIONS

Habitat supply analysis procedures were used to generate a timber harvest schedule that produced a long term sustained yield of deer winter shelter habitat within the Green River Lakes area. The resulting harvest schedule and habitat responses were not unexpected given the mature to overmature state of the softwood forest in the area. In fact, the areas prioritized for harvest by the model fit very closely with areas prioritized for harvest in an earlier management plan developed by Fraser Inc. and DNRE Region 5.

With most of the softwood forest in mature to overmature development stages a decline in shelter habitat from present levels would be inevitable with or without timber harvesting. Timber harvesting results in an immediate decline in potential shelter habitat but serves to shift areas from older to younger development stages. These younger areas will regenerate to provide shelter habitat 45 to 55 years in the future. Without timber harvesting, forest stands would be left to breakup and regenerate naturally over a longer time period. At present, evidence of large scale stand breakup (blowdown) is occurring in a number of locations around First Lake. Though these areas would likely regenerate to softwood and provide shelter habitat in the future, the current age distribution would result in a boom and bust supply of shelter habitat. Over a number of rotations, timber harvesting can create a more even age distribution that will provide a more even flow of shelter habitat.

At the operational level, the outputs of HSA are being used as a guideline to achieve the objective of a sustained supply of shelter habitat. Given operational guidelines for timber harvesting (ie. access, cut size, watercourse buffers, cut block adjacency rules etc.), the full harvest prescribed by HSA will likely not be realized. Therefore, once a long term operational harvest plan is completed, HSA can be rerun to project habitat availability based on what area is actually to be harvested. A lower harvest level is expected to result in the long term supply of shelter habitat to be intermediate between that produced with the no harvest and heavy harvest scenarios.

MODEL USE CONSIDERATIONS

General

The modified version of the FORMAN wood supply model used in this project (WILD2.6) for habitat supply analysis is basically a book keeping function. The model groups forest stands according to similarities in species composition, structure and development stage into forest classes. The forest is then aged in 5 year increments according to volume and habitat relationships (DWA-window) defined for each forest class in a curve set file. Though the model itself is quite simple, errors in a number of the inputs can severely limit its usefulness. These inputs can be broken down into those external to the model, namely the stand attribute information, and those built into the model (PDWA definition, DWA-windows (habitat relationships), timber volume relationships).

Forest Stand Attributes

The most vital information and that most difficult to change is the stand attribute information. Stand descriptions are based on interpretation of 1:12500 aerial photographs. Since the habitat relationships developed for this study (PDWA definition and DWA-Windows) are based on stands being what they are photo-interpreted to be, if errors in interpretation occur to the extent that a significant amount of the area actually belongs to an alternate forest class, then estimates of initial and future habitat availability would be misleading. Wood supply analysis is applied at the license level, and this potential problem is taken into account by treating the forest unit as a label. Timber volume relationships are developed from a sampling of stands across the license that have the same label. When applying timber volume curves developed over a license to a small area, estimated volume yields are suspect since the stands in the area may not reflect the average conditions over the license. With respect to the wildlife habitat relationships developed for this study this potential problem has not been fully investigated and requires major consideration. Ground checks of stand attributes and condition within the study area, planned for the fall of 1989, will allow stands to be reclassified where required.

Potential Deer Winter Shelter Habitat Definition

The definition of which stands may be potential deer winter shelter habitat (PDWA) is based on literature from New Brunswick. Errors in stand attribute information may result in more or less area being assigned as PDWA. Hardwood and hardwood/softwood forest types were not considered for their ability to supply shelter habitat. It is likely that at least some stands that currently fall into one of these two categories have a softwood understorey that could supply future shelter habitat. Where

these conditions are identified the updated information can be incorporated into HSA.

DWA-Window Definition

Definition of the DWA-window is critical to the forecast of shelter habitat availability. Potential implications of errors in the definition have been described (see RESULTS). The DWA-windows derived for this project were based largely on tree species composition and are therefore dependant on the accuracy of the photo-interpretation. In effect there is no real averaging affect as is the case for timber volume estimates described above. This is in some ways an advantage since stand attributes can be updated to what they actually are without affecting the integrity of the model from a habitat supply stand point. It would present a problem however if the technique were applied to large areas where it would be unreasonable to update attributes for all forest stands. As alluded to earlier, the development of wildlife habitat relationships must consider the fact that forest stands are not always what they are photo-interpreted to be and the forest unit serves largely as a label.

Softwood stands that do escape harvest will breakup and regenerate to potentially supply shelter habitat some time in the future. To account for this possibility, a second mode was added to the DWA-window for BFSP stands (160 - 200 years). Little information was available on which to base the age at which BFSP stands could again supply shelter habitat after natural break-up. There is a need to obtain information on how stands may regenerate naturally with respect to both wildlife habitat (stand structure) and wood volume. Without such information it is difficult to model habitat changes in areas where timber harvesting is not the primary objective (ie. deer wintering areas, watercourse buffer strips and wildlife travel corridors).

Spatial Component of Wildlife Habitat

The HSA techniques used in this exercise did not take account of the important spatial aspect of wildlife habitat. For example: deer wintering area (DWA) habitat is most often associated with south facing slopes along water courses and has a shelter component (mature softwood) and a feeding component (regenerating openings). Ideal DWA habitat should have a good interspersion of both components, with small openings not exceeding 4 hectares adjacent to shelter areas of at least equal size which are joined to other shelter habitat by travel corridors. For this exercise it was assumed that shelter habitat occurring anywhere within the study area could be utilized by wintering deer. Such an assumption would be unreasonable to make if the procedure were used at the timber license level. Because of the spatial aspect of wildlife habitat, it cannot be assumed that because there are 1000 hectares of a given forest type (potential habitat "X") on the license that there are actually 1000 hectares of habitat "X". A 1000 hectare block of mature softwood habitat without openings does not provide 1000 hectares of DWA habitat. Therefore, license level HSA, must to some degree incorporate the spatial requirements of wildlife habitat.

CONCLUSIONS

The Green River Lakes Project has provided the opportunity to develop HSA techniques, but more importantly, it has provided insight into the possible applications and limitations of the techniques used in this exercise. The exercise has shown that HSA can be used to guide forest management plan development to achieve given habitat objectives and to evaluate the effects of proposed forest management strategies on habitat availability. A number of important considerations for future HSA development were identified and are listed below.

Future Considerations

General HSA

1. Recognition that FDS stand attribute information is not 100 percent accurate and that the forest unit is a descriptive label for stands that have been interpreted similarly. Without consideration of how these two facts are to be dealt with in HSA the application of species habitat relationships will be difficult.

2. There is a need to be able to model stand development through the natural process of stand break-up and regeneration with particular emphasis on changes in species composition, vertical structure (multi-storeyed stand development) and horizontal structure (crown closure).

3. Must develop the strategy and tools to account for the spatial aspects of wildlife habitat during forest management planning.

4. Development of habitat-type-window curves for the different curve sets forests may follow during the modelling exercise should be explored.

Shelter Habitat Model

If there is an intention to apply this model to other deer wintering areas the following points must be considered.

1. The model requires manual construction of the forest class file and therefore is not suitable for quick application to other areas.

2. The outputs provide a guideline for forest management and will be modified based upon the actual stand conditions and what is operationally feasible to implement on the ground.

3. The DWA-windows should be defined to reflect local conditions.

4. There is a need to obtain accurate up-to-date stand attribute information.

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APPENDICES

APPENDIX 1. Algorithm for 2-age class stands in the Green River Lakes Study Area (class file - Class2pp.grw).

ALGORITHM

Use the first age class unless one of the following conditions is met.

1. All stands which have a harvested condition (partial harvest with residual volume) in first-age class (overstorey) and crown closure (CC) is less than 30 percent (CC < 2 or 62); use second-age class for forest unit and area.

2. If development of first-age class is older than development of second-age class and crown closure of first-age class is lower than crown closure of second-age class; use second-age class for forest unit and area.*

*Exception: If R appears in second age class and crown closure for first-age class is greater-than-or-equal-to 30 percent (CC >= 3 or 63); use first-age class for forest unit and area.

APPENDIX 2. Algorithm for assigning stand ages to forest stands in the Green River Lakes Study Area (class file - Class3pp.grw).

INTRODUCTION

Under license level wood supply analysis, forest class groups are broken down by area into age groups and further assigned to forest classes (class group + age + future curve) based on license level averages determined through sampling. There may be up to 3 ages to which a class group can be broken down. To produce a more accurate representation of the forest structure in the study area, ages were assigned to specific stands within forest class groups. Using the class file Class2pp.grw, stands were listed by class group along with their attributes and the proportions of immature, mature and overmature fir and spruce from photo interpretation. Individual stands within a class group were assigned ages based on the algorithm described below. The procedure was only applied to PDWA forest class groups (softwood and softwood/hardwood). License level averages were used to determine the proportion of area in an age group that would follow a particular future curve (forest class). The resulting forest class file was called Class3pp.grw.

ALGORITHM

One Possible Age

If there is only 1 possible age within an forest class group then all stands are assigned that age.

Two Possible Ages

A - One Storey Stand - 10 Year Age Difference

A1. older age if > 20 percent of composition is overmature

A2. younger age if A1 is not true

B - One Storey Stand - 45 Year Age Difference

B1. younger age if > 40 percent of composition is mature or immature

B2. older age if B1 is not true

C - Two Storey Stand

None exist within study area.

Three Possible Ages

D - One Storey Stand

D1. younger age if percent immature minus overmature is > +20 percent of stand composition

D2. older age if percent overmature minus immature is > +20 percent of stand composition

D3. middle age if D1 and D2 are not true

E - Two Storey Stand

E1. younger age if the second storey is softwood or softwood/hardwood and immature

E2. older age if second storey is softwood or softwood/hardwood and overmature

E3. middle age if E1 and E2 are not true

APPENDIX 3. Deer wintering area shelter habitat supply analysis outputs generated by WILD (FORMAN) Ver.2.6 for the Green River Lakes Study Area.

Table 3. Area (ha) of current potential deer wintering area (CPDWA) and area harvested within the forest defined as potential deer wintering area (PDWA) by period for the Green River Lakes Study Area.

Period (yrs)	CPDWA (ha)	PDWA Harvest* (ha)
1987 + 0	2760	0
5	2252	519
10	1728	521
15	1787	0
20	1705	137
25	1549	111
30	1528	0
35	1431	81
40	1404	0
45	1494	527
50	1509	78
55	1379	289
60	1371	0
65	1488	120
70	1364	124
75	1424	0
80	1411	0

* differs from area harvested in WILD2.6 output (pg.33). WILD2.6 harvest area output represents total area harvested within the Green River Lakes Study Area.

APPENDIX 3 cont'd.

WILD (FORMAN) VERSION 2.6

BACKGROUND HARVEST
HARVEST LEVEL (M3/ITERATION):
80000 80000 0 20000 15000 0 10000 0 65000 10000
25000 0 20000 32500 0 0

PLANTING LEVEL (HA/ITERATION):
50 50 50 50 50 50 50 50 50 50
50 50 50 50 50 50

SPACING LEVEL (HA/ITERATION):
0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0

HARVEST RULES

%	RULE1	%	RULE2	TIME RANGE
100	1 5 0	0	0 0 0	0 - 80

OWNERSHIP: CROWN

CURVE SET FILE: curv5r.s15
FOREST CLASS FILE: class3pp.grw

REPORT ON THE FOREST

	RESIDUAL FOREST					STATISTICS FOR THE PERIOD						
	OPERABLE VOLUME (M3)			DWA(HA)	OTHER WILD	VOLUME CUT (M3)		AREA (HA)			MORTALITY (M3)	
TIME	PRIMARY	SECONDARY	PRODUCT	DEER	LIFE	PRIMARY	SECOND.	CUT	PLANT	SPACE	POT.	REAL.
0	456312.	130385.	298301.	2760.	0.	0	0	0	0	0	0.	0.
5	397940.	120113.	260370.	2252.	0.	80000	18725	735	50	0	9470.	3184.
10	329520.	116161.	211605.	1728.	0.	80000	9729	559	0	0	10876.	6789.
15	316143.	122461.	214575.	1787.	0.	0	0	0	0	0	7850.	7850.
20	283616.	128190.	194552.	1705.	0.	20000	2319	145	0	0	16162.	14712.
25	260938.	136428.	180327.	1549.	0.	15000	1758	117	0	0	15143.	13973.
30	286257.	147128.	194691.	1528.	0.	0	0	0	0	0	22889.	22889.
35	264900.	157126.	180223.	1431.	0.	10000	2181	106	4	0	18854.	17028.
40	253984.	170276.	173376.	1404.	0.	0	0	0	0	0	19565.	19565.
45	193910.	166617.	128213.	1494.	0.	65000	18953	846	50	0	29965.	10707.
50	234990.	174806.	150319.	1509.	0.	10000	4299	131	19	0	14000.	10819.
55	265628.	184176.	165138.	1379.	0.	25000	3237	298	0	0	10721.	7381.
60	283841.	194602.	179127.	1371.	0.	0	0	0	0	0	9934.	9934.
65	275847.	197945.	175986.	1488.	0.	20000	7252	356	50	0	14327.	6031.
70	265669.	198211.	170295.	1364.	0.	32500	10378	419	50	0	8405.	2854.
75	261523.	206949.	171266.	1424.	0.	0	0	0	0	0	13757.	13757.
80	269841.	215638.	177796.	1411.	0.	0	0	0	0	0	11867.	11867.

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APPENDIX 3 cont'd.

WILD (FORMAN) VERSION 2.6

BACKGROUND HARVEST
HARVEST LEVEL (M3/ITERATION):

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0				

PLANTING LEVEL (HA/ITERATION):

50	50	50	50	50	50	50	50	50	50
50	50	50	50	50	50				

SPACING LEVEL (HA/ITERATION):

0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0				

HARVEST RULES

I	RULE1	I	RULE2	TIME RANGE
100	1 5 0	0	0 0 0	0 - 80

OWNERSHIP: CROWN

CURVE SET FILE: curv5r.s15
FOREST CLASS FILE: class3pp.grw

REPORT ON THE FOREST

	RESIDUAL FOREST					STATISTICS FOR THE PERIOD						
	OPERABLE VOLUME (M3)			DWA(HA)	OTHER WILD	VOLUME CUT (M3)		AREA (HA)			MORTALITY (M3)	
TIME	PRIMARY	SECONDARY	PRODUCT	DEER	LIFE	PRIMARY	SECOND.	CUT	PLANT	SPACE	POT.	REAL.
0	456312.	130585.	298301.	2760.	0.	0	0	0	0	0	0.	0.
5	471683.	136602.	313250.	2743.	0.	0	0	0	0	0	9470.	9470.
10	458592.	139788.	309711.	2728.	0.	0	0	0	0	0	22526.	22526.
15	442288.	144193.	305555.	2771.	0.	0	0	0	0	0	19777.	19777.
20	416270.	146609.	289713.	2517.	0.	0	0	0	0	0	28213.	28213.
25	394190.	150542.	275519.	2320.	0.	0	0	0	0	0	28351.	28351.
30	403388.	152880.	278544.	2145.	0.	0	0	0	0	0	39010.	39010.
35	374040.	155211.	258848.	2129.	0.	0	0	0	0	0	35015.	35015.
40	326567.	155575.	225699.	1750.	0.	0	0	0	0	0	52292.	52292.
45	294414.	157096.	202848.	1583.	0.	0	0	0	0	0	41484.	41484.
50	266921.	155974.	182033.	854.	0.	0	0	0	0	0	42724.	42724.
55	250006.	154057.	169920.	652.	0.	0	0	0	0	0	25969.	25969.
60	198751.	151481.	134100.	400.	0.	0	0	0	0	0	64011.	64011.
65	178332.	149163.	120736.	396.	0.	0	0	0	0	0	22790.	22790.
70	153772.	145602.	104857.	395.	0.	0	0	0	0	0	26734.	26734.
75	113129.	142033.	77283.	974.	0.	0	0	0	0	0	40903.	40903.
80	101957.	137206.	70615.	961.	0.	0	0	0	0	0	11493.	11493.

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